Comparison of Cardiovascular Responses to Isometric (Static) and Isotonic (Dynamic) Exercise Tests in Chronic Atrial Fibrillation

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SUMMARY

The aim of the present study was to evaluate the tolerance to various exercises by determining the cardiovascular response to static and dynamic exercises in patients with nonvalvular atrial fibrillation.

Fifty patients (mean age: 63.6±10.3 years; male: 25, female: 25) with chronic (more than one year) nonvalvular atrial fibrillation were included in the study. All patients underwent exercise tests, adjusted appropriately according to their symptoms, as dynamic exercise on a Marquette Case 15 device according to a modified Bruce protocol. Heart rate, and systolic and diastolic arterial pressures were measured at rest and at all stages of the exercise; and the heart rate-pressure products were evaluated. A handgrip test was also conducted as static exercise. The measurements were made before, at the 1st, 2nd and 3rd minutes, and in the recovery periods of the exercise.

The percent values of the changes of the 1st, 2nd and 3rd minute measurements in relation to the initial values for both exercises were compared. In addition, the maximal responses to the exercise tests and the post exercise values were also compared. For statistical evaluations, the paired Student-*t* test was used.

Heart rate and pressure-heart rate product values obtained at 1, 2, and 3 minutes during the treadmill exercise test were significantly high compared to the handgrip values ($P<0.0001$). The arterial systolic and diastolic pressure values in the 1st minute were also significantly higher during the handgrip test ($P=0.0100$ and $P=0.0320$, respectively). The values of diastolic arterial pressure at the 2nd minute during the handgrip test, and systolic arterial pressure at the 3rd minute during the treadmill test were found to be statistically significant ($P=0.0240$, $P=0.0340$, respectively). The mean exercise time and MET value during the treadmill exercise test were 7.18±2.65 minutes and 5.32±1.38 $mL.kg^{-1}.dk^{-1}$, respectively.

During the recovery period, the 5th minute, heart rate and pressure-heart rate product values were significantly high after the treadmill test ($P<0.0001$).

In this study, we revealed that the heart rate response to static exercise was lower and the patients tolerated the static exercise better. Therefore, we decided that the short dura-

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tion of static exercise is not harmful for the noncomplicated chronic atrial fibrillation cases. (Jpn Heart J 2002; 43: 621-629)

Key words: Static exercise, Dynamic exercise, Chronic atrial fibrillation

ATRIAL fibrillation (AF) is a type of arrhythmia seen among the adult population with an average rate of 0.4% and of which the incidence increases with age.[1,2] Exercise is a physiological stress which affects mostly the cardiovascular system. In healthy people, it is known that heart rate (HR) and systolic arterial pressure (SAP) increase during exercise. Patients with AF get tired promptly and have palpitations more frequently due to effort.

The aim of exercise tests is to evaluate the performance and functions of the heart.[3-5] At submaximal exercise levels, HR in patients with AF increases more than in those with sinus rhythm.[6,7] Exercise tests in AF patients are performed mostly in order to ascertain if the ventricular rate is under control by pharmacological treatment, to determine functional capacity, and to plan rehabilitation programs.[6-8]

Isotonic (dynamic) exercise tests, such as treadmill and bicycle ergometer tests, are usually performed with patients and healthy people to investigate the cardiovascular response to exercise. However, frequent usage of static exercises during daily activities and different cardiovascular responses compared to those in dynamic exercise has necessitated the use of static exercise tests.

Static exercise tests are performed using a handgrip dynamometer.[9-12] In recent years, static exercise tests are used for different goals in athletes, coronary artery patients, hypertensives, and healthy people. In many studies, the responses to static and dynamic exercises in healthy people were compared, and it was determined that greater increases in blood pressure (BP) occurred during static exercise and in HR during dynamic exercise.[13-16]

During a literature search, we were unable to find any reports which examined the cardiovascular response to static exercise and compared them with the dynamic exercise test results in AF patients. Therefore, the aim of the present study was to determine the cardiovascular responses to static and dynamic exercises in patients with AF and to evaluate the tolerance to various exercises.

SUBJECTS AND METHODS

Fifty consecutive, nonvalvular, chronic (longer than one year) AF patients who referred to the exercise test laboratory of the Cardiology Institute of Istanbul University were included in the study. Mean age was 63.6±10.3 years and 25

were female and 25 male. All patients underwent a physical examination and transthoracic echocardiography. Valve patients were excluded. Both the dynamic and static exercise tests were performed with all of the patients in the study. All patients were instructed to stop their medications one day prior to testing and to abstain from food and cigarettes for at least two hours prior to testing.

All patients underwent a treadmill exercise test as the dynamic exercise, which was adjusted according to the symptoms, on a Marquette Case 15 device according to a modified Bruce protocol (Table I). A standard ECG, HR, and BP were obtained at rest, during each stage of exercise, and the recovery period, and then the heart rate-pressure product (double-product=DP) was evaluated. DP was calculated as follows.

"DP=SAP mmHg × HR beats/min × 10^{-2} "

The (MET) values of the patients were obtained from the computerized treadmill device recordings.

The static exercise test was performed with all of the patients under the same laboratory conditions after being allowed to rest for at least one hour. Maximal voluntary contraction (MVC) was determined by a handgrip dynamometer device (Takei Kiko Kogyo, Japan) before the static exercise test. The patients were requested to grasp the handgrip dynamometer with their dominant hands, standing up, with their arms 45° lateral and the elbow extended. This process was repeated three times with one minute rest intervals and the mean value was recorded as 1 MVC. The patients were requested to grasp 50% of 1 MVC for 3 minutes without loosening the grip; and they were warned not to perform the Valsalva manoeuvre during the test.

The HR, SAP, and DAP response, and DP at rest, during the exercise at the 1st, 2nd, and 3rd minutes and after exercise at the 1st, 3rd and 5th minutes were eval-

Table I. Modified Bruce Protocol

Stage	Period (minutes)	Grade (%)	Velocity (km/hr)	MET value
1st	3	6	3	3
2nd	3	7	4	5
3rd	3	8	5	6
4th	3	9	6	8
5th	3	10	7	10

MET=multiples of oxygen consumption at rest.

uated; and the 1st, 2nd, and 3rd minute results during exercise and the 5th minute results of the recovery periods of the two tests were compared.

The results were analyzed by the paired Student's *t*-test and are presented as the mean and standard deviation. Statistical significance was accepted at $P \leq 0.05$ level.

RESULTS

Forty-six patients were dominantly right-handed and 4 were dominantly left-handed. Mean MVC was 25.82±5.65 kgw.

The results of an intra-group comparison of the cardiovascular responses during the treadmill and handgrip exercise tests are presented in Table II.

The percent values of the differences in the treadmill and handgrip test results at the 1st, 2nd and 3rd minutes in relation to those at rest are presented in Table III.

The mean exercise period and MET (multiples of oxygen consumption at rest) values were 7.18±2.65 minutes and 5.32±1.38 $mL.kg^{-1}.dk^{-1}$, respectively, in the treadmill exercise test. The mean value of 50% of 1 MVC of the patients for the handgrip test was 12.92±5.5 kgw.

Table II. Intra-group Comparison of Cardiovascular Responses during the Treadmill and Handgrip Exercise Tests

Time	Parameter	Treadmill	*P* value	Handgrip	*P* value
REST	HR	96.89±15.82		92.07±22.05	
	SAP	130.10±17.65		131.02±20.79	
	DAP	82.28± 9.06		84.00±12.48	
	DP	122.49±28.32		119.32±30.18	
1st min	HR	136.67±23.57	<0.0001	92.07±22.14	0.830*
	SAP	132.91±16.10	0.4100*	139.86±25.13	0.058*
	DAP	82.85± 8.76	0.7500*	87.12±13.58	0.230*
	DP	182.28±40.66	<0.0001	125.79±29.91	0.280*
2nd min	HR	146.75±26.18	<0.0001	91.90±20.80	0.850*
	SAP	142.06±16.52	0.0007	142.58±27.00	0.018
	DAP	84.18± 9.21	0.3000*	88.86±16.43	0.099*
	DP	208.88±46.18	<0.0001	129.45±33.99	0.120*
3rd min	HR	154.00±28.80	<0.0001	92.38±20.36	0.930*
	SAP	147.00±18.29	<0.0001	141.96±26.16	0.023
	DAP	85.00± 9.71	0.1500*	87.28±14.53	0.230*
	DP	227.00±52.99	<0.0001	130.73±37.72	0.095*

*=Not significant. HR=heart rate; SAP=systolic arterial pressure; DAP= diastolic arterial pressure; DP=double-product.

The maximal responses to the exercise tests are shown in Table IV.

The HR and DP values at the 5th minute during the recovery period were found to be significantly high following the treadmill test (P<0.0001) (Table V).

DISCUSSION

Table III. Percent Variations in Cardiovascular Responses, in Relation to the Initials, During the Exercise Tests

Time	Parameter (as %)	Treadmill	Handgrip	*P* value
1st min	HR	41.73±17.86	1.56± 9.98	<0.0001
	SAP	2.47± 5.37	6.83±10.46	0.0100
	DAP	0.82± 4.02	4.11± 9.94	0.0320
	DP	45.17±19.33	6.21±13.38	<0.0001
2nd min	HR	52.25±21.01	1.86±11.89	<0.0001
	SAP	9.63± 7.03	8.83±11.70	0.6800*
	DAP	2.48± 5.82	5.90±12.34	0.0240
	DP	66.84±24.80	9.33±18.87	<0.0001
3rd min	HR	60.00±24.31	2.60±12.63	<0.0001
	SAP	13.10± 9.22	8.46±12.11	0.0340
	DAP	3.00± 6.80	4.19±10.71	0.5100*
	DP	81.00±30.96	10.39±22.55	<0.0001

*= Not significant.

Table IV. Maximal Responses to the Exercise Tests

Maximal	Treadmill	Handgrip	*P* value
HR (beats/min)	178.00±22.30	92.38±20.40	<0.0001
SAP (mmHg)	177.60±28.50	142.60±27.00	<0.0001
DAP (mmHg)	87.00±12.30	88.86±16.40	<0.5200*
DP	222.00±45.00	130.73±37.70	<0.0001

*=Not significant.

Table V. Cardiovascular Responses Following the Exercises

Recovery	Treadmill	Handgrip	*P* value
HR (beats/min)	111.15±22.97	86.69±17.29	<0.0001
SAP (mmHg)	128.35±14.48	127.42±21.96	0.8000*
DAP (mmHg)	81.90± 8.00	82.00±12.23	0.9600*
DP	143.54±37.07	109.62±24.35	<0.0001

*= Not significant.

The first physiologic response to exercise of the cardiovascular system, which is under control of the sympathetic nervous system, is an increase in HR. HR increases directly proportional to oxygen uptake and the applied workload.[3] It has been reported that a rapid ventricle response beyond normal was seen at the first stage of static exercise in AF patients[8,17-19] and that this response was higher than in normal subjects.[20]

Hornsten and Bruce[20] demonstrated that 74% of the total variation in HR was at the first stage of exercise in AF patients. Other studies[8,17-20] have found that the increase in HR was maximal at the lowest stage of workload (for example: at 3.0 mph, 0% grade, and under anaerobic conditions) compared to the values at rest; and that less of an increase in HR compared to the first increase occurred at the maximal stage. Therefore, they reported that exercise tests can be used to evaluate the activities of pharmacologic agents for controlling HR in AF patients. Roth, *et al*[21] determined that 66% of the HR variation in 12 AF patients who receive digoxin was in the first minute of exercise. Our study results are in accordance with the investigations mentioned above.

Aberg, *et al*[22] applied a bicycle exercise test to 24 patients with chronic AF who used to receive digoxin. They reported that the ventricular rate increased considerably in the first stage of the exercise in patients with AF, and that this increase was 45% greater than the increase in total heart rate.

Davidson and Hagan,[23] applied an exercise test, limited by symptoms, to patients (mean age 55 years) with chronic AF before and after digoxin administration. They reported that the heart rate decreased from a mean of 163 beats/min to 146 beats/min in the first stage in the patients who received an optimal dose of digoxin, and that there was no significant increase compared to the 1st stage at maximum exercise.

Khalsa, *et al*[24] applied exercise testing to 11 patients with paroxysmal AF, adjusted appropriately according to the symptoms, and found that work load reached a mean of 98 watts and mean HR was 142 beats/min.

DiBianco, *et al*[25] evaluated the effects of nandolol on heart rate using a treadmill exercise test in 20 patients with chronic AF. They reported that at maximum exercise, HR decreased from 175 to 126 beats/min with nandolol.

Other researchers have investigated the effects of static and dynamic exercises on the cardiovascular system in patients with coronary artery disease and in healthy people, and reported that both types of exercise caused considerable increases, mostly in blood pressure and heart rate, respectively.[16,26-29]

Quarry, *et al*[30] demonstrated that a significant increase in BP and a moderate increase in HR occurred during a handgrip test performed with 50% of MVC. DeBusk, *et al*[31] applied a 3-minute static exercise test to 40 cases (mean age 51

years), with 50% of the grasping force, 7 weeks after myocardial infarction. They reported that the HR, SAP, and DP increased to maximums of 91 beats/min, 151 mmHg and 139, respectively. Their study differs from the present study with respect to age and patient group, but on the other hand, resembles our study in terms of the application method and maximal HR response. Maximal BP and DP values in our study remained at lower values.

Lind A[32] compared static exercise with dynamic exercise and pointed out that SAP increased in both exercise types and that the increase in DAP was greater in static exercise. Lind also stated that HR increased considerably while the mean BP value showed only slight alterations in dynamic exercise.

Markiewicz, *et al*[33] compared static exercise test results with those of a treadmill exercise test. Twenty male patients (mean age: 53 years) with myocardial infarction underwent a static exercise test using 20% of their MVC for 2 minutes. The results showed that the HR, SAP, DAP, and DP values increased by 9%, 22%, 21%, and 32%, respectively, in static exercise.

The grasping power in the static exercise protocol used in our study was higher and the exercise period was longer than the study mentioned above. Although the patients with AF in our study were older, the exercise periods were longer and the grasping power values were higher (50%) than the patients with myocardial infarction mentioned above, and the response to static exercise remained at lower values.

Atkins, *et al*[29] investigated the arrhythmia incidence in 45 patients with coronary artery disease using bicycle ergometer and handgrip exercise tests, and determined that atrial arrhythmias were similar for both tests although ventricular arrhythmias were seen more frequently in the static handgrip exercise.

As a result, the static exercise test was reported to be more valuable at unmasking latent ventricular arrhythmias in patients with heart disease. For static and dynamic exercises at peak level, the values of HR, SAP, and DAP were found to be 86±2 minutes, 179±6 mm/Hg, 127±6 mm/Hg; and 122±4 minutes, 167±5 mm/Hg, 94±3 mm/Hg, respectively.

The results for the two types of exercise test in our study are in accordance with the results of Atkins, *et al*.[29]

Major Findings and Conclusion: The present study has revealed the increases in HR at the 1st minute and at the end of the 1st stage (3rd minute) of the treadmill test were 41.73% and 60%, respectively. Furthermore, the increases at these stages were determined to constitute 49.1% and 70.3% of the total HR increase, respectively. The reason for the considerably higher peak values in dynamic exercise compared to those in static exercise is believed to be due to the longer test period and higher work load in the treadmill test (Table IV).

Our most important findings were obtained by comparing the HR responses

of the patients to dynamic and static exercises. In the dynamic exercise test, there was a sudden increase in HR of 41.73% at the beginning (especially at the 1st minute.) which reached 60.00% by the 3rd minute of the exercise. On the other hand, in the static exercise test, minimal changes in HR were found during exercise. It was concluded, based on these results, that the patients adapted better to the static exercise.

We could not compare our results with those in the literature because we were unable to find any study in which handgrip exercise was performed in patients with chronic AF.

As a result, because we obtained different responses to static exercise compared to dynamic exercise in patients with AF, we believe that wider-scale scientific investigations would be beneficial for recommending exercise and planning exercise training programs to subjects.

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